Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences

Maritimes, Gulf, Newfoundland and Labrador, and Quebec Regions

Canadian Science Advisory Secretariat
Science Advisory Report 2012/041

ASSESSMENT OF LEATHERBACK TURTLE (*DERMOCHELYS CORIACEA*) FISHERY AND NON-FISHERY INTERACTIONS IN ATLANTIC CANADIAN WATERS

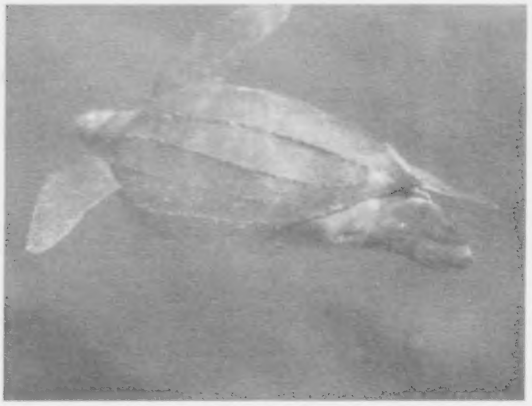

Photo credit: Canadian Sea Turtle Network. Not to be reproduced.

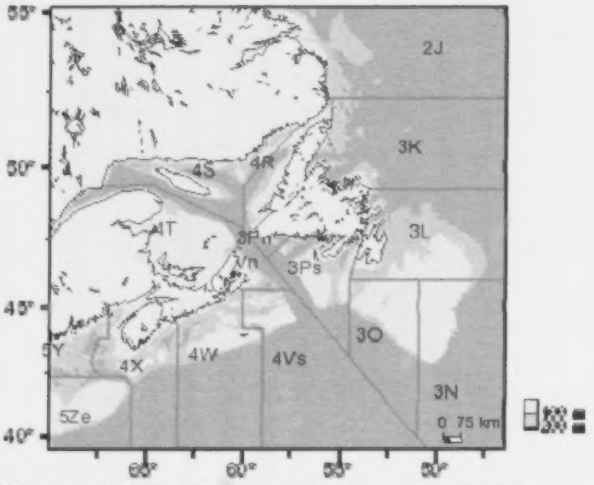

Figure 1. Atlantic Canadian waters and North Atlantic Fisheries Organization divisions.

Context

The status of leatherback turtle (Dermochelys coriacea) in Canadian waters was assessed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in both 1981 and 2001. The species was listed on Schedule 1 of the Species at Risk Act (SARA), and the Recovery Strategy for Leatherback Turtle in Atlantic Canada was posted in 2007 (Atlantic Leatherback Turtle Recovery Team 2006). One objective of the Recovery Strategy is to identify and understand anthropogenic threats to leatherback turtles in Canadian waters, specifically to synthesize and evaluate existing data on commercial fishing and offshore development activities, known to, or having the potential to impact survival and recovery, as well as identify the level of threat to leatherback turtles from marine debris, pollution, and other activities that may pose a threat. The Species at Risk Act requires the Minister to report on the implementation of the Recovery Strategy and progress toward meeting its objectives within five years (2012).

This Science Advisory Report is from March 1-2, 2012, Leatherback Sea Turtle Part 2: Assessment of Fisheries and Non-Fisheries Related Interactions in Atlantic Canadian Waters. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

The intent of this Science Advisory Report is to inform the five-year review of the Recovery Strategy for Leatherback Turtle in Atlantic Canada and to assist in the development of the Action Plan.

Canada

SUMMARY

- In support of a five-year review of the Recovery Strategy and development of an Action Plan for the leatherback turtle in Atlantic Canada, interactions with fisheries and non-fishery activities occurring in Atlantic Canadian waters during 2006 – 2010 were examined.
- Information available to determine encounter and mortality rates for fishery and non-fishery related threats to leatherback turtles in Atlantic Canadian waters was summarized.
- This assessment identified some fisheries interactions that were not identified previously in the Recovery Strategy (e.g., whelk pot). In addition, the geographic analysis of known fisheries interactions has expanded to include the Gulf of St. Lawrence.
- A rough estimate of the mortality rate for large pelagic longline interactions (21-49%) and other fixed gear fisheries (20-70%) has been suggested based on the available information and expert opinion. Further work would be required to determine other fishery-specific mortality rates.
- Data and methods needed to determine current annual mortalities for each fishery require additional work before credible estimates of total leatherback mortality in Atlantic Canadian waters can be provided. However, information provided in this report is expected to contribute towards refinement of an approach to quantify and rank threats to leatherbacks in Atlantic Canadian waters, as well as an approach to estimate total annual mortality.
- The risk of interaction with leatherback turtles and resulting mortality is influenced by management measures, fishing practices, and variation in both spatial and temporal distribution of fishing effort and turtle distributions, such that the relative ranking of threats can change over short time scales.
- Analyses of co-occurrence of fisheries and leatherbacks, as well as information available from sightings networks, are tools to potentially identify and evaluate the threat of fisheries for which observer coverage is limited, as well as to identify fisheries for which mitigation measures should be developed or refined.
- The ability to detect and evaluate fishery and non-fishery interactions remains low. Co-occurrence of vessel traffic with leatherback distribution in Atlantic Canadian waters indicates that the threat of vessel collisions with leatherbacks may be larger than the documented interactions would suggest. Seismic noise and marine debris (plastics) remain potential but undocumented threats to leatherback turtles in Atlantic Canadian waters.
- Cumulative impact and impact trends need to be interpreted in the context of concurrent changes in total Atlantic leatherback population size.

INTRODUCTION

Rationale for Assessment

The Recovery Strategy for leatherback turtle in Atlantic Canada was published in February 2007 (Atlantic Leatherback Turtle Recovery Team 2006). The *Species at Risk Act* (SARA) requires that the competent minister report on the implementation of the Recovery Strategy and progress toward meeting its objectives within five years of inclusion in the public registry (February 2012 in the current case). DFO Science was asked to assess the level of leatherback turtle fishery and non-fishery interactions in Atlantic Canadian waters. Specifically,

- What are the current sources of interactions with fisheries in Atlantic Canadian waters?
  - What level of mortality is caused by each identified source; and
  - Are these levels increasing or decreasing?

- What are the current sources of other, non-fisheries related interactions,
  - What level of mortality is caused by each source; and
  - Are these levels increasing or decreasing?

The information provided in this advisory report will be used by the Species at Risk Program in the five-year review of the leatherback turtle Recovery Strategy and in the development of the associated Action Plan.

Species Biology and Ecology

The leatherback turtle (*Dermochelys coriacea*) is the most widely distributed, and largest of all marine turtles. In the Canadian Atlantic, leatherbacks may attain curved carapace lengths of 175 cm, and weigh 640 kg (James et al. 2007). Genetics and tag-recapture data confirm that leatherbacks in Canadian waters originate from nesting beaches in the wider Caribbean; South and Central America; and Florida, USA (James et al. 2007; Goff et al. 1994). The species primarily feeds on soft-bodied, gelatinous organisms, such as medusae (sea jellies), salps, and siphonophores, prey that are seasonally abundant in temperate shelf and slope waters off eastern Canada. Some leatherbacks from the western Atlantic undertake annual migrations to Canadian waters to forage (James et al. 2005). While found throughout Atlantic Canadian waters, leatherback turtles are often concentrated in what is thought to be important foraging habitat (Figure 2). Leatherback turtles can be found in Atlantic Canadian waters at all times of the year but can be found in greatest abundance from June – October.

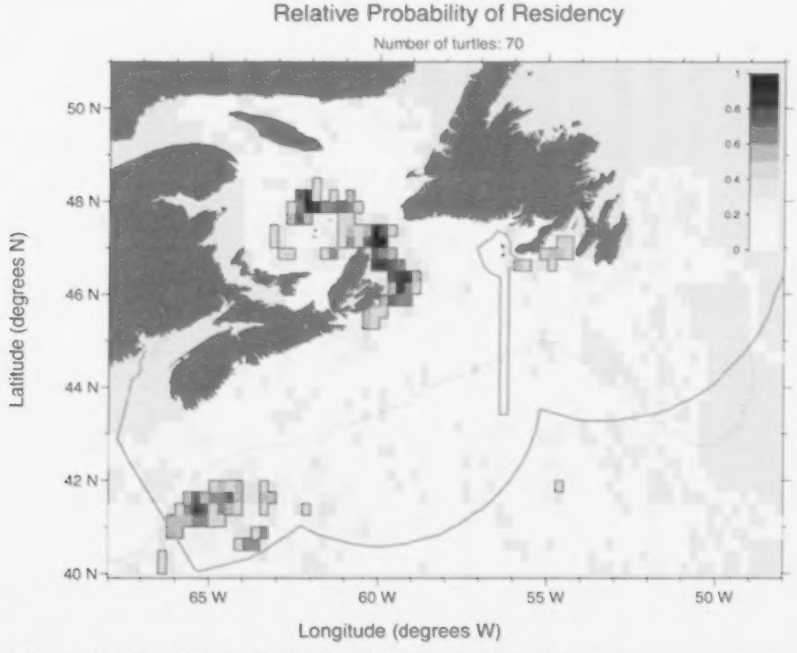

Figure 2. Areas of important habitat for leatherback turtles in Canadian waters, as indicated by satellite telemetry. Scale represents aggregated residency probability. Red polygons denote areas where aggregated residency probabilities ≥0.4 for all satellite tracked turtles. Thick grey line indicates Atlantic Canadian Exclusive Economic Zone boundary; thin grey line indicates 1000 m isobath. Source: M.C. James and I.A. Jonsen unpublished data; as presented in DFO 2012. Not to be cited outside the context of this zonal advisory process.

While foraging in continental shelf waters off Canada's Atlantic coast, leatherbacks spend approximately two thirds of their time in the top 6 m of the water column. Their maximum dive depths seldom exceeding 50 m, and about 50% of their day and evening hours (0900-2100) are spent at the surface (James et al. 2006). Dive behaviour off the shelf is characterized by deeper maximum dive depths and longer dive durations. This is likely due to changes in foraging tactics for those turtles continuing to exhibit seasonal residency (James et al. 2005), and broader behavioural shifts accompanying the initiation of southward migration (Jonsen et al. 2007).

ASSESSMENT

Sources of Data

A variety of information sources aid in the analysis of threats to leatherback turtles in Atlantic Canadian waters.

Observer programmes conducted by each of the four DFO regions (Newfoundland and Labrador (NL), Quebec, Gulf, and Maritimes) have provided information on the bycatch of almost 147,000 fishing sets conducted on the Atlantic Coast during 2001 – 2010. While the programme has been conducted since 1977, it is only more recently that protocols have been introduced to ensure that leatherback encounters are accurately recorded, including species identified, encounter method categorized, and release state reported. This dataset can be a useful source of information on encounter rates in observed fisheries, as knowledge of percent observer coverage can be used to scale results to the entire fishery. Leatherback records in this dataset are generally rare, with only one interaction recorded off Newfoundland in 2000, one interaction recorded in the Gulf of St. Lawrence in 2008, and 143 interactions recorded off the Scotian Shelf.

Sentinel and Atlantic halibut surveys have been conducted during June – October by the four DFO regions since the early 1990s using fixed gear (longline and gillnet) that might be expected to interact with leatherback turtles. None of these surveys have reported leatherback entanglements.

Since 2005, DFO has introduced monitoring requirements that fishery encounters with species listed under SARA be recorded in specially designed **SARA logbooks**. While there has been incomplete fishery coverage, issues with compliance, and confusion about how and when to complete the SARA logbooks, making analysis of these logs challenging. However, they provide evidence of interaction between leatherbacks and a variety of fishing gear types since 2005. There have been 10 encounters off NL (6 in fixed gear and 4 in mobile gear) reported by the NL Region, 19 in the Gulf of St. Lawrence (17 of these with fixed gear) reported by the Quebec (18) and Gulf (1) regions, and 100 off the Scotian Shelf (99 with pelagic longline, 1 with a lobster trap) reported by the Maritimes Region.

Volunteer **strandings and sightings networks** have provided anecdotal information on fishery interactions with leatherbacks off Newfoundland and Labrador since 1976 (Whale Release and Strandings, NL), off Nova Scotia since 1998 (Canadian Sea Turtle Network), and in the Gulf of St. Lawrence (Turtle Observation Network). Only the Whale Release and Strandings, NL data was presented in this assessment (Ledwell and Lawson 2011). Estimation of reporting rates, including potential changes over time, would assist with analysis of this type of data.

The analysis of non-fishery threats is limited to inferences from the temporal and spatial distribution of seismic surveys based on reports from the Canada Nova Scotia Offshore Petroleum Board (CNSOPB) and the Canada Newfoundland and Labrador Offshore Petroleum Board (CNLOPB); vessel counts from the Long Range Identification and Tracking system; a long-term time series of offshore marine debris conducted since 1986 by the Sea Education Association in Woods Hole, Massachusetts of the eastern seaboard of the USA and a coastal marine debris monitoring program conducted by the Great Canadian Shoreline Cleanup program since 2003. None of these activities have explicitly recorded interactions with leatherback turtles but provide important information on the risk of interaction.

Fishery Threats

The potential co-occurrence and reported interactions with a variety of fisheries were examined in this assessment (Appendix 1). Where "encounter mortalities" are indicated, they refer to mortalities observed at the time of the encounter and do not include any post-release mortality.

Fixed Gear Fisheries

Fixed gear fisheries other than the pelagic longline fishery were not evaluated in detail in the previous DFO assessment (DFO 2004; Sinclair 2004). Additional information is now available to assist with evaluation of these fisheries in the four Atlantic regions.

An attempt was made to estimate the mortality rate for leatherback turtles that encounter fixed gear other than that used in the pelagic longline fishery based on analysis of Canadian release reports and published literature. SARA logbooks suggest an encounter mortality rate of 20%, and the Whale Release and Strandings, NL reports suggest an encounter mortality rate of 23%, but these are considered a minimum estimate based on likely reporting bias. James et al. (2005) assert that the risk to leatherbacks entangled in fixed gear includes the possibility of drowning as a consequence of the tidal cycle, and the magnitude of the threat fixed gear poses to leatherbacks has not been adequately recognized nor addressed. Ryder et al. (2006) estimate post-release mortality from large pelagic longline gear of 60% if monofilament line is still attached to the turtle when it is released but with no hook involved. No estimates were provided in Ryder et al. (2006) of post-release mortality from other types of gear. In the absence of other information, but recognizing that injuries from rope and other types of fixed gear may be different than injuries from monofilament line, it was suggested that the 60% post release mortality estimate described above be added to the encounter mortality estimate to provide a very rough estimate of the overall mortality rate for fixed gear in the range of 20-70%.

Whelk Pot Fishery

The whelk pot fishery was not evaluated in the previous DFO assessment of leatherback interactions (DFO 2004; Sinclair 2004). The whelk pot fishery on the Canadian east coast occurs almost exclusively in the summer to fall (June – October), with the heaviest fishing in North Atlantic Fisheries Organization (NAFO) Division 3Ps. This fishery is also conducted in the French waters of St. Pierre and Miquelon, on the NL south coast; however, the threat to leatherbacks that occur in these waters has not been evaluated in this report. While the Canadian whelk fishery is small in scale compared to other fixed gear fisheries, it tends to occur in important leatherback habitat (as identified in DFO 2012, Figure 2). This presumably increases its co-occurrence, and hence risk, to leatherback turtles. Observer records of this fishery are limited (<1% observer coverage) with 192, 90, and 16 sets observed by the DFO NL, Quebec/Gulf, and Maritimes Region programs, respectively, with no corresponding leatherback interactions. However, there are a number of reports of entanglements of leatherback turtles

from the SARA logbooks: 2 from the NL Region and 10 from the Quebec Region (release condition was not consistently reported). There have been 5 entanglements (3 encounter mortalities) reported by Whale Release and Strandings, NL. These records suggest that interaction and potential mortality of leatherbacks with the whelk pot fishery is greater than the limited observer data would suggest. Available data are insufficient to determine whether the risk of interaction with this fishery is increasing or decreasing.

Lobster Trap Fishery

The Canadian east coast lobster fishery is primarily prosecuted during the winter – spring (November – May) season, but this varies by area. During the summer – fall (June – October), the largest fishery is in NAFO divisions 4T (Lobster Fishing Area 25), 4Vn, and the offshore waters of the Scotian Shelf (4VWX, which is the area of a year-round fishery). The lobster fishery is widely distributed in coastal waters, where there is almost no positional information provided other than by unit area and little observer coverage. The offshore lobster fishery in the Maritimes Region has had some observer coverage (ranging 0.3 – 6% by area), but there are no records of interactions with leatherback turtles. There have been no leatherback encounters reported in the NL Region SARA logs. There was one report of a leatherback entanglement in the Maritimes Region SARA logs (LFA 29, released alive). In the Quebec Region, there was one entanglement (2010) in a lobster trap. The Maritimes and Quebec Region SARA logs suggest that interaction of leatherbacks with the lobster fishery may be greater than the limited observer data would suggest. Available data are insufficient to determine whether the risk of interaction with this fishery is increasing or decreasing.

Snow Crab Trap Fishery

The snow crab trap fishery is roughly split evenly between the summer – fall and winter – spring seasons. There are three major components to the summer – fall fishery: one operating in NAFO divisions 3K/3L, another in 4T, and a third in 4VW. During 2006-2010, observer coverage in 4VWX was in the order of 8-10% per year, coverage of 4T has been in the order of 12%, and coverage in NL ranged from 2-18%. During 2001 – 2005, there were 3 leatherback entanglements reported, and during 2006 – 2010 there were 2 leatherback entanglements reported in the Maritimes Region observer database (turtle condition not described). There are no observer reports of leatherback interactions in the Gulf or NL snow crab fisheries. Based on the observer data, an encounter rate in the 4VWX snow crab fishery in the order of 5.5 encounters per year might be expected. Applying a fixed gear mortality rate of 20-70% would suggest mortality in the range of 1-4 deaths per year. It should be noted that the snow crab fishery in 4VW has been shifting increasingly to a spring fishery to avoid interaction with soft-shelled snow crab, which may reduce the potential for interaction with leatherback turtles. Similarly, part of the fishery for snow crab in the southern Gulf of St. Lawrence occurs in the spring.

There were 7 entanglements in crab gear reported to Whale Release and Strandings, NL; 2 reported in snow crab gear (released alive) and 5 reported in other crab pots (3 encounter mortalities). These reports would suggest that the encounter rate in this fishery may be larger than is suggested by the observer data.

Mackerel Trap Fishery

There have been no observer records of interactions with the mackerel trap fishery, and only one Gulf Region SARA logbook report of an entanglement with the mackerel trap fishery (released alive). However, there were two interactions reported to Whale Release and

Stranding, NL (released alive). These reports indicate that the risk of interaction with the mackerel trap fishery is likely higher than would be determined through analysis of DFO observer records. Available data are insufficient to determine whether the risk of interaction with this fishery is increasing or decreasing.

Hagfish Trap Fishery

The hagfish fishery was not evaluated in the previous DFO assessment of leatherback interactions (DFO 2004; Sinclair 2004). An analysis of the co-occurrence between leatherback turtles and the hagfish fishery in the Maritimes (1999-2007; Brillant, S.W. [Canadian Wildlife Federation], Canadian Sea Turtle Network, and World Wildlife Fund-Canada; unpublished data) indicated a low risk of interaction. There have been no reports of interactions with hagfish traps in either the observer database or SARA logbooks. Data are insufficient to determine whether the risk of interaction with this fishery is increasing or decreasing.

Herring Gillnet Fishery

The Canadian east coast herring gillnet fishery effort is most intense during the summer – fall. Much of the fishery occurs in NAFO Division 4T, although there is a component of the fishery in the Scotian Shelf – Bay of Fundy area. There is very low observer coverage in the herring gillnet fishery (<1%), with no reported leatherback interactions. There was 1 leatherback turtle interaction reported in the Quebec Region SARA logbooks, which occurred within the Gulf of St. Lawrence. There were 4 reports of leatherback turtle encounters in herring gillnets to Whale Release and Strandings, NL (released alive). Data are insufficient to determine whether the risk of interaction with this fishery is increasing or decreasing.

Turbot (Greenland Halibut) Gillnet Fishery

The Canadian east coast turbot gillnet fishery is prosecuted primarily during the summer – fall. During this season, much of the fishery occurs north of the Scotian Shelf with a large fishery in the Gulf and off Newfoundland. While the turbot gillnet fishery is relatively large, it does not occur predominantly in important leatherback habitat (as identified in DFO 2012, Figure 2). During 2006 – 2010, the percent observer coverage averaged 29.5% in NAFO Division 3L and 4.8% in 4RST. Overall, observer coverage was relatively good compared to other fixed gear fisheries with no observed interactions with leatherback turtles. However, there were two records of interactions in the NL SARA logbooks (released alive) in 2006. Data are insufficient to determine whether the risk of interaction with this fishery is increasing or decreasing.

Groundfish Gillnet Fishery

The groundfish gillnet fishery catches a wide variety of groundfish species. The fishery is prosecuted mostly in the summer – fall period, with much of the summer – fall landings reported from NAFO Divisions 3L, 3Ps, 4R, and 4X.

There have been almost 10,000 sets observed in this fishery during 2001 – 2010, although the coverage by NAFO division has been variable, and coverage of the most important areas of the fishery (3KL, 3Ps4R, and 4X) can be considered low (less than 2%). There have been no reported interactions between this fishery and leatherback turtles in the observer database since 2001. However, SARA logbooks from the NL Region reported two entanglements in 2005, with both turtles released alive. There were no reports of leatherback encounters from any of the other three regions. According to Whale Release and Strandings, NL, encounters with groundfish gillnet gear since 1976 represented the highest number (33) of the 75 records (27

released alive). These reports suggest that the potential for interaction and, thus, mortality from this fishery may be higher than would be determined from DFO records, especially off Newfoundland. Data are insufficient to determine whether the risk of interaction with this fishery is increasing or decreasing.

Mackerel Gillnet Fishery

There were 4 interactions between the mackerel gillnet fishery and leatherback turtles reported to Whale Release and Strandings, NL (2 encounter mortalities). Data are insufficient to determine whether the risk of interaction with this fishery is increasing or decreasing.

Large Pelagic Longline Fishery

The large pelagic longline fishery occurs almost exclusively during summer to fall, primarily on the Scotian Shelf. Encounters with leatherback turtles have been monitored in the large pelagic longline fishery since 2001, and efforts have been made both to reduce these encounters (changes to gear, i.e., switch to circle hook) and to reduce the impact of encounters should they occur (handling protocols). There were 102 reported interactions with this fishery in the observer database from 2001 to 2005, and 36 reported interactions from 2006 to 2010 (Figure 3).

Figure 3. Spatial distribution of 138 leatherback turtles observed in large pelagic longline fishery during 2001 – 2011; note group of observations east of Flemish Cap that were recorded during 2001 – 2003.

Observer coverage has ranged from 5-30% since 2001, with rates currently in the order of 10% (lower on the Grand Banks). Since 2002, coverage has generally increased on the Scotian Shelf and decreased on the Grand Banks. Based on an analysis by Hanke et al. (2011), the encounter rate in this fishery is estimated to have declined from 120 – 190 per year prior to 2006 to 60 – 90 per year since then (Figure 4).

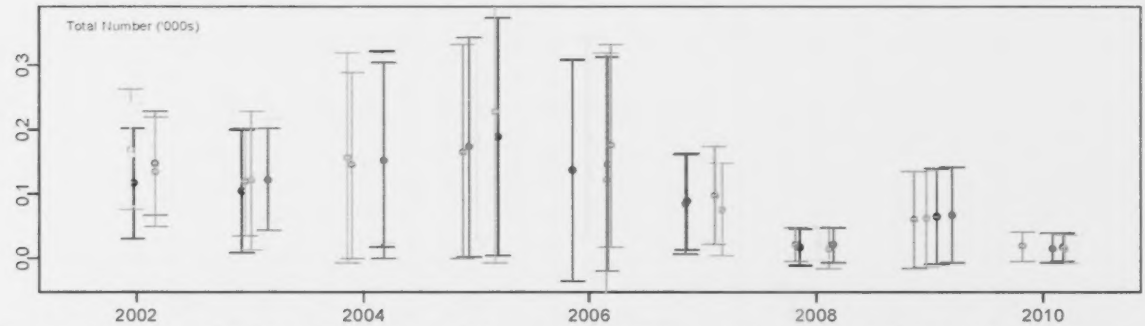

Figure 4. Estimate of total leatherback bycatch numbers based on total weight of a trip's catch, weight of Swordfish kept (target), number of hooks, number of sets and number of sea days) with 95% confidence interval (from Hanke et al. 2011).

Mortality rates are estimated to be in the range of 21-49%, with 21% representing the current rate estimated for this fishery in the USA (based on protocols that are increasingly implemented by the Canadian fishery) and 49% representing the rate as estimated from Canadian observer records since 2006 (reported condition of release in Canadian records translated into USA categories with associated post-release mortality rates). Applying these rates to the observer-based encounter estimates would result in an estimated mortality rate of 13 – 44 leatherbacks per year.

Atlantic Halibut Longline Fishery

The fishery in the Canadian zone occurs primarily during summer – fall, although there is a sizeable fishery during the winter – spring. During the summer – fall, much of the fishery occurs in NAFO Division 3Ps and Subarea 4. While the halibut fishery is comparable in scale to the large pelagic longline fishery, there are no records of interactions in the observer database (coverage is variable and ranged 1 to 30% during 2006-2010 depending on the area), the halibut survey, or the SARA logbooks. The reasons for the limited interaction or reports of interaction with this fishery are unknown but may be related to the fact that this is a bottom fishery with a limited amount of floating surface gear.

Groundfish Longline

The Canadian east coast groundfish longline fishery directs for and catches a wide variety of groundfish species, including cod, haddock, pollock and white hake. During 2006 – 2010, landings of this fishery decreased from about 14,000 t to 10,000 t. The majority of these landings are made during the summer to fall. Much of the summer to fall fishery occurs in NAFO Divisions 3Pn, 3Ps, 4R, 4X, and 5Ze. With observer coverage in the range of 2 – 30% depending on area, there have been no reported interactions between this fishery and leatherback turtles in the observer database since 2001. However, there have been three reports from the Quebec Region SARA logbooks (one in 2006 and two in 2008) in the area of the Magdalen Islands. Ten reports of encounters (4 encounter mortalities) with groundfish longline gear have been made to Whale Release and Strandings, NL since 1976. These reports indicate that the risk of interaction and, thus, mortality from this fishery is greater than is suggested by the observer database. There are limited differences between halibut longline gear and groundfish longline gear (e.g., hook size), but the groundfish longline fishery tends to occur in shallower water.

Mackerel Handline

There was one interaction with mackerel handline gear reported in a Quebec Region SARA logbook in 2008. Data are insufficient to determine whether the risk of interaction with this fishery is increasing or decreasing.

Mobile Gear Fisheries

There is a much lower risk of interaction between leatherback turtles and mobile fishing gear than fixed gear due to the reduced amount of line or rope left in the water. However, leatherbacks may still be captured within mobile trawls and purse seines. The mortality rate associated with these types of interactions is estimated to be high.

Groundfish Trawl Fishery

There was one observed leatherback interaction with a redfish trawl in the Gulf of St Lawrence (observer database). This may be the same interaction that was reported in a Quebec Region SARA logbook. There is one additional SARA logbook record from Quebec Region reporting an interaction with a halibut trawl. There was one groundfish trawl interaction (mortality) reported to Whale Release and Strandings, NL. Data are insufficient to determine whether the risk of interaction with this fishery is increasing or decreasing.

Shrimp Trawl Fishery

With the introduction of the Nordmore grate (1991 in the Maritimes Region), the risk of interaction with the shrimp trawl fishery is considered to be low. There have been no reports of interactions with leatherback turtles in the observer database since 2001 (up to 5% observer coverage). However, there was one SARA logbook report of interaction from the NL Region (released alive) in 2009.

Mackerel Purse Seine Fishery

There were 3 SARA logbook reports of interaction with the mackerel purse seine fishery from the NL Region (released alive). Data are insufficient to determine whether the risk of interaction with this fishery is increasing or decreasing.

Analysis of Co-Occurrence – Preliminary Results

Preliminary results of an approach to estimate the relative risk of fisheries interactions was presented for consideration.

Leatherback turtle satellite telemetry data (source: Canadian Sea Turtle Network) were used to map the seasonal presence of 72 leatherback turtles during 1995-2009 within Atlantic Canadian waters using 3 minute grid cells. These maps were then compared to maps of Maritimes and Gulf Region commercial fishing activity during 1999-2001, 2002-2004, and 2005-2007 (Figure 5). Fisheries investigated to date included crab, groundfish longline, groundfish gillnet, pelagic longline, herring gillnet, hagfish, and offshore lobster. Monthly estimates of the relative risk of entanglement by each fishery were estimated as the probability of a leatherback turtle to occur in the same place and time as fishing gear. This was done for each of the three-year periods.

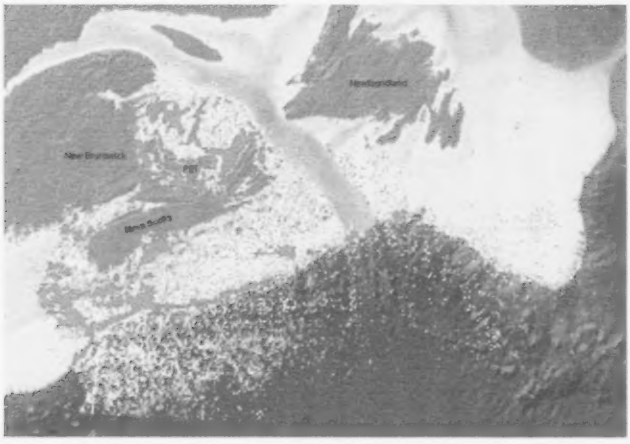

Figure 5. Distribution of fishing activity included in the co-occurrence analysis (1999-2007). Note: Maritimes and Gulf Region fisheries data only. Source: Brillant, S.W. (Canadian Wildlife Federation), Canadian Sea Turtle Network, and World Wildlife Fund-Canada; unpublished data; not to be cited outside the context of this zonal advisory process.

This analysis indicated that the crab fishery (primarily snow crab) had the greatest relative risk for leatherback turtles during 1999-2007; however, the relative risk from this fishery decreased from 72% to 48% during that time (Figure 6). The relative risk from groundfish longline increased from 14% during 1999-2001 to 24% during 2005-2007. Relative risk from groundfish gillnet increased from 8% to 14% over these periods, and relative risk from pelagic longline increased from 4-5% to 9%. Relative risk from the other fisheries was less than 4%. Changes in the risk of interaction during this time period are related to a number of factors, including changes in total effort, shifts in fishing season, or shifts in fishing location. Information from this analysis is based on unpublished research from Brillant, S.W. (Canadian Wildlife Federation), Canadian Sea Turtle Network, and World Wildlife Fund-Canada and should not be cited outside of the context of this zonal advisory process.

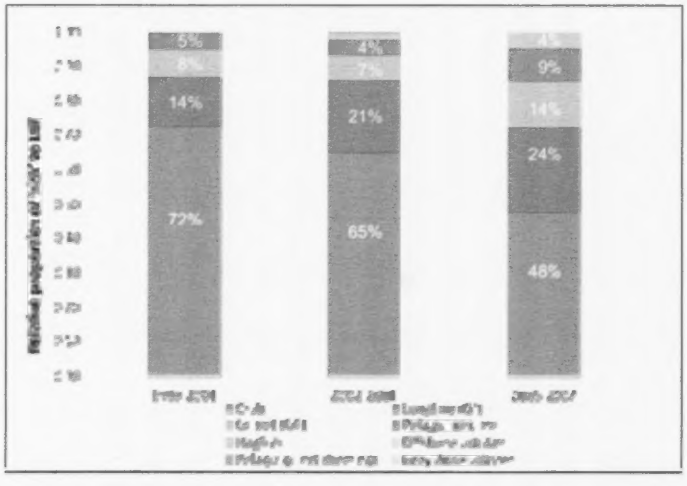

Figure 6. Contribution of each fishery examined in this analysis to the total relative risk of leatherback entanglement in Atlantic Canadian waters, for each three-year period from 1999-2007. Source: Brillant, S.W. (Canadian Wildlife Federation), Canadian Sea Turtle Network, and World Wildlife Fund-Canada; unpublished data; not to be cited outside the context of this zonal advisory process.

Next Steps

While reports of the encounters between leatherback turtles and specific fisheries are useful for determining potential sources of mortality, it is the encounter rate (along with the mortality rate) in each fishery that is required to estimate the total annual level of fishery-related mortality in Atlantic Canadian waters. Where observer coverage captures a representative sampling of a particular fishery, and leatherback interactions are recorded appropriately, this information can be used to estimate the encounter rate for that fishery. Where observer coverage is limited, estimated encounter rates for one fishery could be used as a proxy for encounter rates in similar types of fisheries, based on the amount, location in the water column, and types of line or rope rather than on trap type as key threat factors. Geographic location of the fishery, including tidal influences, and fishery timing are other factors to consider.

In addition, analyses of co-occurrence of fisheries and leatherbacks, as well as information available from sightings networks, are tools to potentially identify and evaluate the threat of fisheries for which observer coverage is limited, as well as to identify fisheries for which mitigation measures should be developed or refined. Estimates of the reporting rates for volunteer sightings networks, though complicated by potential changes in the perceived consequences of reporting over time, could enable use of these data as an additional source of information when estimating encounter rates.

Non – Fishery Threats

The non-fishery threats to leatherback turtles off Atlantic Canada include seismic noise, vessel collisions, and ingestion of marine debris.

Seismic Noise

Petroleum exploration-related seismic surveys have been conducted off Newfoundland and on the Scotian Shelf during 1998 – 2005, with less activity on the Scotian Shelf since then. Conducted during the core leatherback season, these surveys could be interacting with leatherbacks. Even during the most active years for the Scotian Shelf area (1997 – 1999), surveying occurred primarily along the edge of the Shelf (Figure 7) and did not generally occur in the important leatherback habitat identified in DFA 2012 (Figure 2), though it did occur in other areas used by turtles. While impacts of seismic noise are considered the primary threat from seismic surveys, interactions with seismic gear may also be possible (speculative).

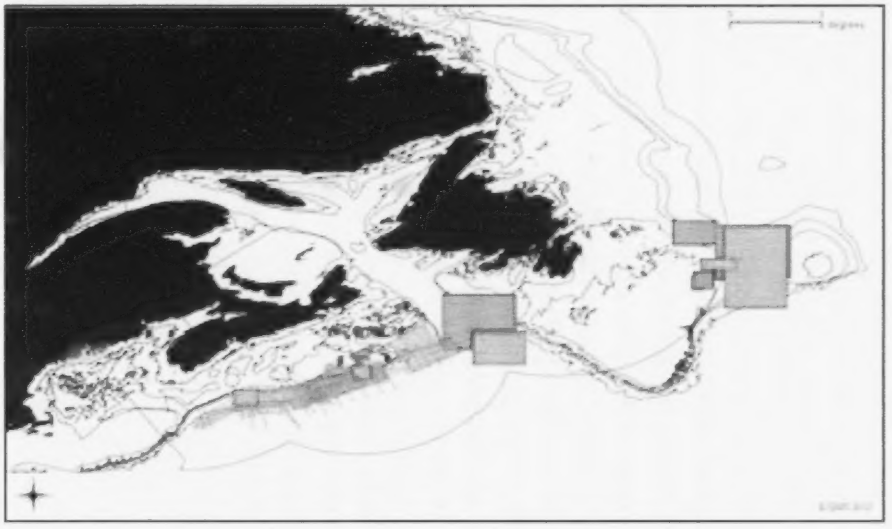

Figure 7. Spatial distribution of 2-dimentional (2D) and 3-dimentional (3D) seismic surveys during 1997 (blue), 1998 (red) and 1999 (green); for surveys off Newfoundland, only the bounding latitudes and longitudes of the survey area are indicated.

Knowledge of the impact of seismic energy on leatherback turtles is limited (Eckert et al. 1998). Sea turtles are known to be able to detect and respond to the frequencies used during seismic surveys (Lee et al. 2011). Seismic surveys can illicit physical, physiological, and behavioural responses in other species (e.g., loggerhead and green turtles), with impacts that are likely to be local and short–term. No studies have indicated mortality as a consequence of seismic surveys. There are very few studies of population–level effects, and it is likely that any impact could not be measurable against the background natural variability. Overall, it is not possible to estimate leatherback mortality, if any, due to seismic energy off the Atlantic coast since 2001. Given the area covered by seismic surveys and the knowledge of impacts, mortality may be low but this is considered a knowledge gap. Whatever the level of impact, it has diminished on the Scotian Shelf since 2005 due to a reduction in the number of seismic surveys conducted on the Scotian Shelf in recent years. However, seismic activity continues at a relatively high level in Newfoundland and Labrador waters.

Vessel Collisions

In temperate shelf waters of the Northwest Atlantic, most leatherback activity occurs in the top 6–12 m of the water column, which exposes leatherbacks to collisions with marine vessels. There is very limited observational information on this threat. There has been at least one recorded vessel strike in Canadian waters, and 20% of stranded leatherbacks off Florida had propeller marks (Eckert et al. 2009), primarily from small vessels. While it is not always possible to determine whether these marks were inflicted pre or post mortem, preliminary information indicates that a significant number (in the order of 50%) are likely the cause of death. Figure 8 illustrates a 12-month composite (March 2010 – February 2011) of vessel track counts within Canada's Atlantic region based on Long Range Identification and Tracking (LRIT) system data (Koropatnick et al. 2012), which does not account for smaller fishing vessels, recreational vessels, or ferries. Given the considerable marine activity in Atlantic Canadian waters, including considerable vessel traffic through important leatherback habitat (as identified in DFO 2012, Figure 2), there is potential for interaction and mortality as a result of this activity. Thus, while there is little documented mortality of leatherbacks due to vessel collisions in Atlantic Canadian

waters, the risk of vessel collisions is likely higher than the documented interactions would suggest.

Ingestion of Marine Debris

Ingestion of marine debris, including planktonic plastic, poses a threat to leatherbacks, leading to both sub-lethal and lethal effects. A study of 408 turtle autopsies conducted during 1885 – 2007 indicated that 34% of the specimens contained plastic, with an increase in occurrence since 1950, corresponding with the growth in plastic manufacturing (Mrosovsky et al. 2009). Law et al. (2010) show that the highest concentration of plastic in the Northwest Atlantic occurs off the USA east coast and in areas used by leatherbacks (Figure 10). While plastic discards from USA east coast municipal waste sites has been increasing since 1985, the average plastic concentration (pieces km^{-2}) has remained relatively unchanged, leading to speculation on ocean processes that might be removing plastic from the upper levels of the water column. There is also some indication that the size of plastics in the marine environment is decreasing.

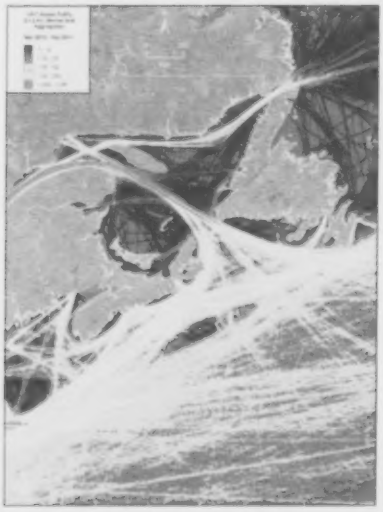

Figure 8. Twelve-month (March 2010–February 2011) composite raster of vessel track counts per 2 x 2 minute grid cell (Atlantic region view) based on Long Range Identification and Tracking system data. (Source: Koropatnick et al. 2012)

Figure 9. Distribution of plastic marine debris collected during 1986 - 2008 in the western North Atlantic Ocean and Caribbean Sea; symbols indicate location of each net tow; colour indicates measured plastic concentration in pieces km^{-2}; black stars indicate tows with measured concentration greater than 200,000 pieces km^{-2}; symbols are layered from low to high concentration. (Source: Law et al. 2010)

Sources of Uncertainty

There are a number of uncertainties that prevent precise estimates of impacts of human activities on leatherback turtles occurring off Canada's Atlantic Coast. Observation rate within an activity would need to be high to provide reliable estimates of the interaction between that activity and leatherback turtles. Observer coverage of many fisheries is very low, in some cases below 1%. Further, sampling allocation problems have been identified in some fisheries (i.e., large pelagic longline), which further increases the uncertainty. While data on leatherback encounters are available through DFO SARA logbooks and some volunteer strandings /

sightings networks, there is limited information on reporting rates, which prevent use of these data in quantitatively estimating population–level impacts. Notwithstanding this, these additional data sources are useful in broadly indicating the scale of fishery impacts on leatherbacks. There are limited data on the mortality rates for leatherbacks either upon encounter with fishing gear or subsequently upon release from this gear. For non-fishery impacts, while there are indications of potential impacts of some threats, there are limited observations in Atlantic Canada to suggest that these are occurring. These uncertainties constrain inferences of human impacts on leatherbacks to crude estimates based upon those threats for which representative estimates of impact can be obtained.

CONCLUSIONS

In support of a five-year review of the Recovery Strategy and development of an Action Plan for the leatherback turtle in Atlantic Canada, interactions with fisheries and non-fishery activities occurring in Atlantic Canadian waters during 2006 – 2010 were examined.

Information available to determine encounter and mortality rates for fishery and non-fishery related threats to leatherback turtles in Atlantic Canadian waters was summarized. Methods for collection of data on leatherback turtle interactions in the SARA logbooks, sentinel survey, and observer database was reviewed and issues identified (e.g., compliance with SARA log requirements, observer reporting protocols). Recommendations include: standardized data collection and a centralized database to help with future analysis.

This assessment identified some fisheries interactions that were not identified previously in the Recovery Strategy (e.g., whelk pot). In addition, the geographic analysis of known fisheries interactions has been expanded to include the Gulf of St. Lawrence.

A rough estimate of the mortality rate for large pelagic longline interactions (21-49%) and other fixed gear fisheries (>20%) has been suggested based on the available information and expert opinion. Further work would be required to determine other fishery-specific mortality rates. Better understanding of gear configuration and operation may help to refine mortality rates.

Data and methods needed to determine current annual mortalities for each fishery require additional work before credible estimates of total leatherback mortality in Atlantic Canadian waters can be provided. However, information provided in this report is expected to contribute towards refinement of an approach to quantify and rank threats to leatherbacks in Atlantic Canadian waters, as well as an approach to estimate total annual mortality.

The risk of interaction with leatherback turtles and resulting mortality is influenced by management measures, fishing practices, and variation in both spatial and temporal distribution of fishing effort and turtle distributions, such that the relative ranking of threats can change over short time scales. Separation of turtles from gear in time and space is one potential explanation of why gear that might be expected to interact with turtles does not appear to; issues with reporting compliance is another possible explanation.

Analyses of co-occurrence of fisheries and leatherbacks, as well as information available from sightings networks, are tools to potentially identify and evaluate the threat of fisheries for which observer coverage is limited, as well as to identify fisheries for which mitigation measures should be developed or refined.

Recognizing the important contributions of industry and others who report interactions and implement mitigation measures, it is expected that information gathered from these sources would be used to support their efforts to enhance the survival and recovery of leatherback turtles.

The ability to detect and evaluate non-fishery interactions remains low. Co-occurrence of vessel traffic with leatherback distribution in Atlantic Canadian waters indicates that the threat of vessel collisions with leatherbacks may be larger than the documented interactions would suggest. Seismic noise and marine debris (plastics) remain potential but undocumented threats to leatherback turtles in Atlantic Canadian waters.

Cumulative impact and impact trends need to be interpreted in the context of concurrent change in total Atlantic leatherback population size, i.e., any increase or decrease in the rate of interactions must be interpreted in the context of concurrent changes in total leatherback population size. Development of an index of the success of mitigation measures to reduce impacts to leatherbacks would need to take this into account.

SOURCES OF INFORMATION

This Science Advisory Report is from the March 1-2, 2012, Leatherback Sea Turtle Part 2: Assessment of Fisheries and Non-Fisheries Related Interactions in Atlantic Canadian Waters. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

Atlantic Leatherback Turtle Recovery Team. 2006. Recovery Strategy for Leatherback Turtle (*Dermochelys coriacea*) in Atlantic Canada. *Species at Risk Act* Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa, vi + 45 pp.

DFO. 2012. Using satellite tracking data to define important habitat for leatherback turtles in Atlantic Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/036.

DFO. 2004. Allowable Harm Assessment for Leatherback Turtle in Atlantic Canadian Waters. DFO Sci. Stock Status Rep. 2004/035.

Eckert, K.L., B.P. Wallace, J.G. Frazier, S.A. Eckert, and P.C.H. Pritchard. 2009. Synopsis of the Biological Data on the Leatherback Sea Turtle, *Dermochelys coriacea* (Vandelli, 1761). Prepared for the U.S. Fish and Wildlife Service under P.O. #20181-0-0169 and Grant Agreement # 401814G050. 203 pp.

Eckert, S.A., A. Bowles, and E. Berg. 1998. The effect of seismic airgun surveys on leatherback sea turtles (*Dermochelys coriacea*) during the nesting season. A report by the Hubbs-Sea World Research Institute for BHP Petroleum, Sandiego, CA.

Goff, G., J. Lien, G.B. Stenson and J. Fretey. 1994. The migration of a tagged leatherback turtle, *Dermochelys coriacea*, from French Guiana, South America, to Newfoundland Canada, in 128 days. Can. Field-Nat. 108 (1):72-73.

Hanke, A.R., I. Andrushchenko, and G. Croft. 2011. Observer coverage of the Atlantic Canadian swordfish and other tuna longline fishery: an assessment of current practices and alternative methods. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/049.

James, M.C., C. A. Ottensmeyer, and R.A. Myers. 2005. Identification of high-use habitat and threats to leatherback sea turtles in northern waters: new directions for conservation. Ecology Letters, 8: 195–201.

James, M.C, S.A. Sherrill-Mix, K.E. Martin, and R.A. Myers. 2006. Canadian waters provide critical foraging habitat for leatherback turtles. Biol. Conserv. 133: 347-357.

James, M.C., S.A. Sherrill-Mix, and R.A. Myers. 2007. Population characteristics and seasonal migrations of leatherback sea turtles at high latitudes. Mar. Ecol. Prog. Ser. 337: 245 – 254.

Jonsen.I.D., R.A. Myers, and M.C. James. 2007. Identifying leatherback turtle foraging behaviour from satellite telemetry using a switching state-space model. Mar. Ecol. Prog. Ser. 337:255-264.

Koropatnick, T., S.K. Johnston, S. Coffen-Smout, P. Macnab, and A. Szeto. 2012. Development and Applications of Vessel Traffic Maps Based on Long Range Identification and Tracking (LRIT) Data in Atlantic Canada. Can. Tech. Rep. Fish. Aquat. Sci. 2966.

Law, K.L., S. Morét-Ferguson, N.A. Maximenko, G.Proskurowski, E.E. Peacock, J. Hafner, and C.M. Reddy. 2010. Plastic Accumulation in the North Atlantic Subtropical Gyre. Science. 329: 1185 – 1188.

Ledwell, W., and J.W. Lawson. 2011. Whale release and strandings network off Newfoundland and Labrador. http://www.newfoundlandwhales.net/ (Accessed January 25, 2012).

Lee, K., S.L. Armsworthy, S.E. Cobanli, N.A. Cochrane, P.J. Cranford, A. Drozdowski, D. Hamoutene, C.G. Hannah, E. Kennedy, T. King, H. Niu, B.A. Law, Z. Li, T.G. Milligan, J. Neff, J.F. Payne, B.J. Robinson, M. Romero, and T. Worcester. 2011. Consideration of the Potential Impacts on the Marine Environment Associated with Offshore Petroleum Exploration and Development Activities. DFO. Can. Sci. Advis. Sec. Res. Doc. 2011/060: xii + 134p.

Mrosovsky, N., G.D. Ryan, and M.C. James. 2009. Leatherback turtles: The menace of plastic. Marine Pollution Bulletin 58(2): 287-289.

O'Boyle, R. 2012. Assessment of Leatherback Turtle (*Dermochelys coriacea*) fishery and non-fishery related interactions in Atlantic Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/063.

Ryder, C.E., T.A. Conant, and B.A. Schroeder. 2006. Report of the Workshop on Marine Turtle Longline Post-Interaction Mortality. U.S. Dep. Commerce, NOAA Technical Memorandum NMFS-F/OPR-29, 36 p.

Sinclair, M. 2004. Proceedings of a Regional Advisory Process Meeting on the level of allowable mortality for leatherback turtles in support of species at risk. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2004/011.

APPENDIX

Appendix 1. Summary of information available to assess fisheries threats to leatherback turtles in Atlantic Canadian waters. Mar=Maritimes, NL=Newfoundland and Labrador, Q=Quebec, and G=Gulf. PCM=post capture mortality.

	Scale of Fishery	Observer Database		SARA logbooks	Whale Release and Strandings, NL	Mortality Rate
	Average annual number of trips (2006-2010)	Encounters (2006-2010)	% Coverage	Reports (2005-2011)	Encounters (1976-2010)	Estimate
Fixed Gear Fisheries						
Whelk pots	1,627	0	<1%	2 NL 10 Q	5	
Inshore lobster traps				1 Q 1 Mar		
Offshore lobster	104,755	0 Mar 0 NL	0-6%	0		
Snow crab pots	12,773	2 Mar 0 NL 0 G/Q	8-10% Mar 2-18% NL ~12% G	0	2	
Other traps/pots				0	Other crab: 5 Cod trap: 1	
Mackerel traps				1 G	2	
Herring gillnet	8,552	0 NL	<1%	1 Q	4	
Turbot gillnet	1,928		3-55%	2 NL		
Groundfish gillnet	24,038	0 NL 0 Mar 0 G/Q	0.4-20%	Cod: 2 NL	33 Other gillnet: 4	20-70%
Mackerel gillnet					4	
Mackerel handline				1 Q		
Groundfish longline	7,132	0 NL 0 Mar 0 G/Q	2 - 30%	Cod: 3 Q	10	
Halibut longline	1,997	0 NL 0 Mar 0 G/Q	1 - 30%			
Large pelagic longline	451	38 Mar 0 NL 0 G/Q	5-30%	99 Mar	67	21-49%
Other					4	
Mobile Gear Fisheries						
Groundfish trawl		Redfish: 1 G/Q		Halibut: 1 Q Redfish: 1 Q	1	
Shrimp trawl		0	0 – 5%	1 NL		
Mackerel purse seine				3 NL		
TOTAL		**41**		**129**	**142**	

FOR MORE INFORMATION

Contact: Tana Worcester
Centre for Science Advice – Maritimes Region
Fisheries and Oceans Canada
Bedford Institute of Oceanography
Polaris Bldg., 4th Fl. (Mail Sta. B203)
PO Box 1006, 1 Challenger Drive
Dartmouth, Nova Scotia B2Y 4A2
Tel: (902) 426-9920
Fax: (902) 426-5435
E-Mail: Tana.Worcester@dfo-mpo.gc.ca

This report is available from the:

Centre for Science Advice (CSA)
Maritimes Region
Fisheries and Oceans Canada
PO Box 1006, Station B203
Dartmouth, Nova Scotia
Canada B2Y 4A2

Telephone: 902-426-7070
Fax: 902-426-5435
E-Mail: XMARMRAP@mar.dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs

ISSN 1919-5079 (Print)
ISSN 1919-5087 (Online)
© Her Majesty the Queen in Right of Canada, 2012

La version française est disponible à l'adresse ci-dessus.

CORRECT CITATION FOR THIS PUBLICATION

DFO. 2012. Assessment of Leatherback Turtle (*Dermochelys coriacea*) Fishery and Non-fishery Interactions in Atlantic Canadian Waters. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/041.